ELECTRONICS PERSONNEL RESEARCH

DEPARTMENT OF PSYCHOLOGY
UNIVERSITY OF SOUTHERN CALIFORNIA

Technical Report No. 5

A COMPARISON OF THE EFFECTS OF FOUR DISPLAY CONDITIONS ON THE DISCRIMINATION LEARNING OF SIMULATED SONAR ECHO-RETURNS

August 1953

Project Designation NR 153-093

Contract Nonr-228(02)

Principal Investigator

William W. Grings

Project Director

Joseph W. Rigney

DEPARTMENT OF PSYCHOLOGY

UNIVERSITY OF SOUTHERN CALIFORNIA

PREFACE

This report is the eighth in a series published by the Electronics Personnel Research group. The first seven were based on shipboard observation of electronics personnel aboard ships of the destroyer class. The eighth, ninth, and tenth reports describe the results of collateral research which was done concurrently with this shipboard observation. Their subject matter will differ from that of the first seven reports; consequently, their titles are listed below, with a brief description of their contents.

8. <u>A Comparison of the Effects of Four Display Conditions on the Discrimination Learning of Simulated Sonar Echo-Returns</u>.

   A report of the results of a laboratory study of discrimination learning, employing stimulus patterns of short duration, presented by means of aural, visual, and combined aural-visual displays.

9. <u>A Methodological Study of Electronics Trouble Shooting Skill: I. Rationale for and Description of the Multiple-Alternative Symbolic Trouble Shooting Test</u>.

   A description of a new type of test format designed for measuring some aspects of trouble shooting skill, and a discussion of the conception of trouble shooting on which it is based.

10. <u>A Methodological Study of Electronics Trouble Shooting Skill: II. Intercomparisons of the MASTS Test, a Job-Sample Test, and Ten Reference Tests Administered to Fleet Electronics Technicians</u>.

    A report of the results of the administration of the two forms of the MASTS Test, a job-sample test, and a battery of achievement and ability oriented reference tests to a sample of ETs from ships undergoing repairs in the Long Beach Naval Shipyard.

ACKNOWLEDGMENTS

The research reported in this series reflects the contribution of a large number of persons within the Military Establishment. Grateful appreciation for this assistance is extended to the Cruiser Destroyer Force, Pacific; the Training Command, Pacific; the Training Division and the Personnel Analysis Division, Bureau of Naval Personnel; the Personnel and Training Branch of the Psychological Services Division of the Office of Naval Research; and the Electronics Coordinator's Section of the Office of the Chief of Naval Operations.

ABSTRACT

This is a report of a study of the relative effects of an aural, a visual, a simultaneous aural and visual, and two stimulus orders of a successive aural-visual display on the discrimination learning of short pulses of electrical energy translated into visual and auditory stimuli.

TABLE OF CONTENTS

II. THE PROBLEM

A. The Context

Operational experience with sonar suggests that certain characteristics of echo-returns are correlated with differential features of the objects which reflect them. It is conceivable that this correlation can be improved to the extent that a particular echo-return pattern will be a dependable referent for a particular kind of reflecting object. Efforts to improve the correlation through machine design should be paralleled by studies of the operator's ability to learn the correlates which become available to him. So long as there is a human element in the system, echo-returns will have to be translated into sensory data which a human can perceive, discriminate, attach meaning to, and report to the next element in the system. At the present time, these data are in the form of complex patterns of short temporal duration which are displayed for the operator either in aural or visual terms.

An important part of this problem of increasing the reliability of the man-machine link is the effect of mode of presentation on discrimination learning of stimulus patterns similar to those which might contain referents of target characteristics. The sensory channel, as well as the specific manner of display of the electronic signal as a stimulus pattern, are involved in mode of presentation. Vision and hearing are the usual human input channels in military information systems.

B. The Purpose

The present study undertook a comparison of the effects of four

different types of displays on the discrimination learning of a series of stimulus patterns of short duration, differing chiefly in terms of envelope shape. The four types of displays were: aural, visual, simultaneous aural and visual, and two stimulus orders of a successive display. The two orders represented were aural followed by visual, and visual followed by aural.

It was expected that the experiment would reveal which of the four displays led to the most learning of the stimulus material in a fixed number of presentations. The combined displays were included to permit the study of the effects of presenting signals in terms of the two sensory channels, with respect to intermodality transfer, facilitation, or interference of learning. The results should have implications for training and human engineering activities dealing with sonar problems.

C. The Hypotheses

The specific experimental questions for which answers were sought are stated below as hypotheses to be tested by the experimental design. The stimulus patterns referred to are shown in their visual form in Figure 1. They are described in the section on Instrumentation. The hypotheses refer to these specific visual stimuli and their aural counterparts, as presented by the various displays.

1. In a fixed number of trials, there will be a difference between the amount of discrimination learning of the visual stimulus patterns, when they are presented either separately or as components in compound patterns, and that of the aural patterns, presented either separately or as components in compound patterns.

2. When aural and visual stimulus patterns are presented successively or simultaneously by means of combined displays, in a fixed number of trials there will be a difference between the amount of discrimination learning of the patterns in each modality and that of the patterns in each modality when they are presented separately by means of simple displays.

3. When an aural and a visual stimulus pattern are paired in successive presentations by means of a successive display, in a fixed number of trials there will be a difference between the amount of discrimination learning of the pattern occurring second in each presentation and that of the pattern occurring first.

4. Of the combined display conditions, only the simultaneous display will lead to the formation of compound stimulus patterns learned a different amount in a fixed number of trials than their component parts are learned during these same trials.

5. When aural and visual stimulus patterns are presented successively, in a fixed number of trials there will be a difference between the amount of learning which occurs in each modality and that which occurs in each modality when the aural and visual patterns are presented simultaneously.

6. Number of amplitude peaks will be an easier cue for discrimination among the stimulus patterns than shape of amplitude peaks.

III. THE METHOD

The test of the foregoing hypotheses required a laboratory situation permitting the presentation of electronic information by visual and auditory means in such a manner that stimulus characteristics could be controlled. This was provided by recording the signals on magnetic tape and reproducing them through earphones or a cathode ray oscilloscope. In addition, a measure of subject responses was necessary which could serve as a dependent variable in evaluating performance change.

A. Instrumentation and Stimulus Patterns

In the planning stages of the experiment, it was necessary to decide whether to attempt to use actual sonar outputs or to synthesize the material to be learned. Recordings of sonar echo-returns made under operating conditions at sea would have been realistic. However, such echo-returns typically contain a great deal of uncontrollable noise as an accompaniment of the signal, and the differences among such echo-returns in terms of discriminable characteristics have not as yet been fully worked out.

In view of these considerations, it was decided to synthesize the stimulus patterns. A device consisting of two gear-driven potentiometers with switches at both ends of their cycles was constructed. This device was connected between the output of an audio-oscillator and the inputs of an oscilloscope and a tape recorder. The oscillator was set at 500 cps, with enough gain to produce a clearly audible tone of medium intensity.

With this arrangement it was possible to produce a large sample of patterns, to time their durations by the grids on the scope face, and to record the patterns as they were produced. Five basic stimulus patterns were selected from this sample. These were cut from the tape and spliced together to serve as the prototype of the tape used in the experiment. The five basic patterns were recorded on the tape in counterbalancing orders, so that each of the patterns occurred once each trial and equally often in the five different positions in the series. An interval of 15 to 20 seconds, varied at random between the individual patterns, allowed the subject time to respond and to get set for the next presentation.

The shapes in Figure 1 are reproductions of the visual outlines of the basic patterns, and are labelled A, B, C, D, and E. All the patterns but E were of 165 milliseconds duration. Pattern E was 90 msec. and was the simplest in contour, being merely one short pulse with only one amplitude peak. It was included to give subjects an easy discrimination at the beginning of the learning process. Pattern C had three amplitude peaks; A, B, and D each had two amplitude peaks.

The displays were produced by different combinations of three groups of apparatus: a recorder section, earphones, and a cathode ray oscilloscope with a driven sweep circuit. Two Revere T-500 recorders were ganged together in the recorder section. Only one of these was necessary for all but the successive display, since the output of one recorder could be fed to earphones and oscilloscope through the same lead for the simultaneous display. The ganging was accomplished by placing the magnetic head of one recorder in the tape path of the other recorder so that the tape would play through both heads. The drive mechanism of only one of the machines was used.

Since the interhead interval was 3¾", and the tape speed of this type of recorder drive is 3¾" per second, an interval of one second resulted between the time a recorded signal passed the first head and the time it passed the second. This interval could be preserved in the successive display by connecting the output of one recorder to the earphones and of the other to the cathode ray oscilloscope.

The oscilloscope was a DuMont 304-H, an instrument which has a triggering circuit in the sweep generator, using the signal to start the sweep. Sweep speed was set on two cps in the experiment.

The observable referent for a discrimination was switch-pressing. After each stimulus presentation, the subject was required to press

one of five switches on a console, corresponding to the five different basic patterns. His task was to learn the switch associate for each pattern as well as to discriminate among the patterns. The five switches were connected to five indicator lights on the experimenter's console. By observing the lights, the experimenter could tell which switch had been pressed and record the correctness or incorrectness of the subject's response.

A selector switch on the experimenter's console was in series with these five switches and a small green indicator light was placed on the subject's console. The experimenter could preset the light to come on only when the subject pressed the correct switch, giving the subject knowledge of results.

B. Experimental Design and Procedure

1. Outline of the Experimental Design. The experiment was conducted in two sessions: a learning session, followed after a rest period of five minutes by a test session. Therefore, there were two groups of experimental conditions and two groups of data resulting from the experiment.

A learning session consisted of 20 repetitions of the five stimulus patterns under one of the four display conditions. This meant that each subject was given 20 learning trials, with five successive discriminations to perform per trial, or with a total of 100 successive discriminations to perform. After performing each discrimination, the subject pushed one switch on his console. There were, then, 100 switch-pressing responses per subject in a learning session, or 20 such responses for each of the five stimulus patterns.

A test session consisted of either two or three tests, depending on the display condition, each composed of five repetitions of the same basic five stimulus patterns, for a total of 25 successive discriminations. During the tests, the reinforcing light was disconnected. Again, switch-pressing was the referent for a discrimination, so that there were 25 switch-pressing responses in one test, or a total of five such responses per stimulus pattern.

Those subjects who learned the stimulus patterns under the simple display conditions, aural or visual, were given two tests: one on stimulus patterns in the same modality in which they were learned, and the other with compound simultaneous aural-visual patterns. The subjects who learned the stimulus patterns under a combined display condition, simultaneous or successive, were given three tests: an aural, a visual, and a compound simultaneous aural-visual. In all cases, the order of administration of the tests followed a counterbalancing procedure to control order and sequence effects.

The experiment used five 18-subject groups: one group for each of the display conditions: aural, visual, and simultaneous, and two groups

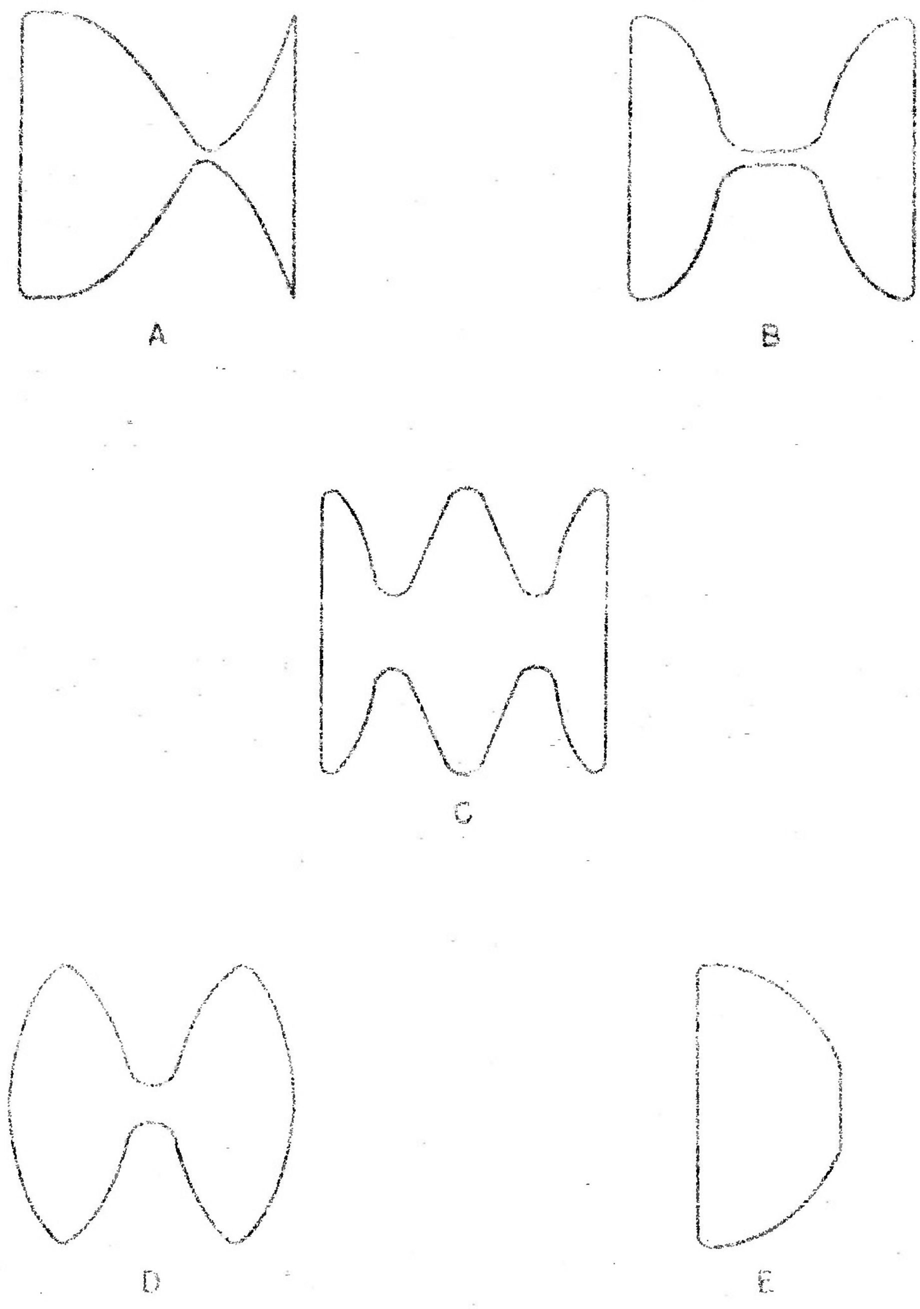

FIG. I. CONTOURS OF THE FIVE VISUAL STIMULUS PATTERNS.

for the successive display, since two stimulus orders were to be used. One group learned the stimuli in the aural-visual order in a successive pair, the other group learned the stimuli in the visual-aural order in a successive pair. The five groups were made up by random assignment of volunteer student subjects. Each subject was assigned by a randomization procedure to one of the five display groups and again by a similar procedure to one of the test order groups.

The outline below summarizes the experimental design, the learning and test session conditions, and the means which were to be obtained from the data. Using the first row, opposite Subject Group I, as an example, and reading across, the phrase "aural display" means that Subject Group I learned the stimulus patterns in the learning session under the aural display condition. "I Ma" is the mean number of correct responses per stimulus pattern made by all eighteen subjects in Group I during the learning session. This mean was obtained by finding the mean number of correct responses each subject in the group made per stimulus pattern in 20 trials, summing these means and dividing by 18, the _n_ of a subject group.

Next, "aural, compound" refers to the two types of tests administered to Subject Group I in the test session. The aural test used the aural display and consequently, auditory stimulus patterns; the compound test used the simultaneous aural-visual display with its resulting compound patterns. "_I_ Ma, _I_ Mc" refers to the means computed for the test data. Where the roman numeral is underlined, it indicates the statistic was from the test session. These means were calculated in a fashion similar to that used for the training session means.

The mean referred to by _I_ Ma, for example, was computed by finding for each subject the mean number of correct switch-pressing responses made per stimulus pattern during the five repetitions, or trials of a test. (Note that the word trial is used to include the five successive discriminations performed among the five basic stimulus patterns presented in one trial.) Then, these individual subject means were summed and divided by 18, the _n_ in a subject group, to yield a statistic expressing the mean number of correct switch-pressing responses per stimulus pattern made in five trials by eighteen subjects.

2. The Dependent Variable. In both training and test sessions, the dependent variable was based on the number of correct switches pushed during the session. In the learning session, the dependent variable was the mean number of correct switch-pressings per stimulus pattern made by the eighteen subjects in a group during the 20 repetitions of the five stimulus patterns. In the test session, the dependent variable was the mean number of correct switch-pressings per stimulus pattern per test made by the eighteen subjects in a group in the five repetitions of the five stimulus patterns during a test.

3. The Independent Variables. There were four in the experiment: (1) the display conditions, (2) the envelope variations of the stimulus patterns, (3) the interstimulus interval in the compound displays, and (4) the modality order in the successive compound displays.

4. The Controlled Variables. The intensity of the aural and visual stimulus patterns was held constant by maintaining the gain settings of the recorders and the Z-axis gain of the oscilloscope constant. The duration of the patterns was controlled at the time they were synthesized, by measuring their duration on the oscilloscope screen. All the patterns but one were of the same duration, within the limits of the equipment used for reproducing them. The interstimulus interval varied randomly between 15 and 20 seconds, determined by the length of tape between recorded pulses. Individual differences were randomized across the four display groups. Sex differences were included with individual differences and consequently also were random with respect to the display groups. Subject set was controlled by standardized instructions.

5. Procedure. At the beginning of the experiment, the subject was given written instructions to read. After making sure these were understood, the experimenter reduced room illumination, demonstrated the switches and the reinforcing light and cautioned the subject against trying a system of responding rather than performing the discriminations. The subject was shown the first three to five patterns and allowed to listen to them without responding.

The first responses of the subject were necessarily trial and error until he began to discriminate among the patterns and to learn which switch was associated with a particular pattern. The experimenter recorded the subject's responses and preset a selector switch for the reinforcing light.

After twenty repetitions of each stimulus pattern, the training session ended. The subject was given five minutes rest while the experimenter adjusted the equipment for the test session. The subject was instructed that his task would be the same during the test session as it was during the learning session, except that the reinforcing light would not come on to tell him when his response was correct. The test session then began, the tests being given in the order determined at the time the subject groups were composed.

IV. THE RESULTS AND DISCUSSION

A. The Results

The training and test session means are reproduced in Table 2. Each of these is the mean number of correct responses made by the eighteen

Table 1

Outline of the Experimental Design

Subject Groups	Training Session	Training Session Means	Test Session	Test Session Means
I	aural display	I Ma	aural, compound	I Ma, I Mc
II	visual display	II Mv	visual, compound	II Mv, II Mc
III	simultaneous display	III Mc	aural, visual, compound	III Ma, III Mv, III Mc
IV	successive display, aural-visual	IV Mav	aural, visual, compound	IV Ma, IV Mv, IV Mc
V	successive display, visual-aural	V Mva	aural, visual, compound	V Ma, V Mv V Mc

Table 2

Training and Test Session Means

Subject Groups (n = 18)	Training Session	Training Session Means	Test Session	Test Session Means
I	aural	10.74	aural	3.40
			compound	3.27
II	visual	7.17	visual	2.05
			compound	2.41
III	simultaneous	9.14	aural	2.54
			visual	2.82
			compound	3.55
IV	successive (av)	8.42	aural	2.57
			visual	2.11
			compound	2.68
V	successive (va)	8.47	aural	2.70
			visual	2.57
			compound	3.03

Note: Training session means are mean number of correct responses per stimulus pattern in a group of 18 subjects out of a total of 20 responses to each stimulus pattern.

Test session means are mean number of correct responses per stimulus pattern in a group of 18 subjects out of a total of 5 responses to each stimulus pattern.

subjects in a display group during a total of 20 repetitions of the stimulus patterns for the training session and 5 repetitions of the patterns for each of the tests in the test session. The format of the table corresponds to that of Table 1.

The group learning under the aural display condition had the highest learning session mean, the simultaneous display group mean was next, the two successive group means third, and the visual display group mean was lowest. Statistically significant differences among these means are summarized in Table 3 in the appendix.

Of the test series means, that for the compound test administered to the simultaneous display group was the highest (3.55), followed by that for the aural test given to the aural display group (3.40). The tests of significance of differences among these and the learning session means are summarized in Table 3 in the appendix.

Figure 2 shows the learning curves fitted to the learning session data, combining the two successive display stimulus orders. (The difference between training session means of these two successive orders was not significant.) The curves are parabolas of the general equation $y = ax^b$. It is evident that the rate of discrimination learning was highest for the aural display group, the combined displays groups were intermediate, while the visual display group had the lowest rate.

The predictions made in the hypotheses were tested in terms of differences between paired means listed in Table 2. (The tests of the significance of these differences are summarized in Table 3 in the appendix, in terms of the specific predictions made in the hypotheses.) The general results of the experiment are stated below.

The aural stimulus patterns were the easiest to learn: reflected in the fact that the aural display group had the largest mean number of correct responses in the training session (10.74), while the visual display group had the lowest mean (7.17) for this session. This difference between the effects of the two simple displays was apparent in the test session means of their respective groups, and continued to show up in the means of the successive display groups.

On the whole, the combined displays, simultaneous and successive, were intermediate between the simple (aural and visual) displays in their effects on discrimination learning of the patterns, insofar as that learning was measured in each modality separately. However, the simultaneous combined display did lead to the formation of compound stimulus patterns which were retained at least as well as the aural stimulus patterns; indicated by the fact that in the test session the compound test mean for the simultaneous group was numerically higher than any of all the other test session means. Within the simultaneous group it was significantly higher than the aural and visual stimulus pattern test means, suggesting that the simultaneous presentation did result in a patterning effect.

Order of presentation of the stimuli in the successive displays failed to produce a significant difference between the means of the aural and visual tests for these successive groups. However, there was a consistent trend in the data. All three test means were higher for the visual-aural order than for the aural-visual order.

Within each successive display group, there were no significant differences between test means. Apparently, the one second interstimulus

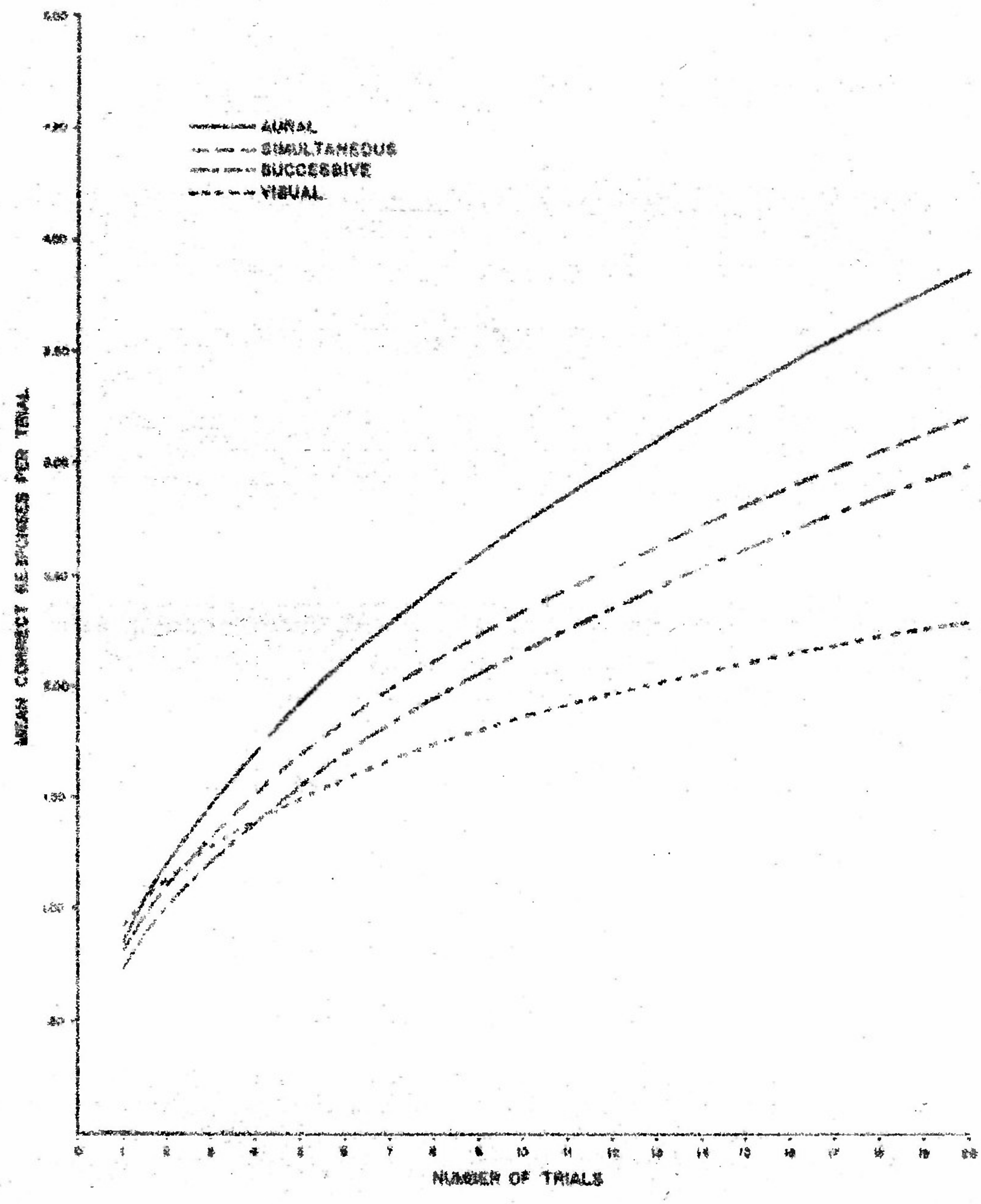

FIG. 2 THE EFFECTS OF FOUR DISPLAY CONDITIONS ON THE RATE OF LEARNING OF FIVE STIMULUS PATTERNS.

interval was sufficient to prevent the patterning effect produced by the simultaneous display.

The relative difficulty of the five stimulus patterns, both aural and visual, so far as discrimination learning is concerned, was as predicted. The order of difficulty, from hardest to easiest, was A, B, D, C, and E. Number of amplitude peaks proved an easier cue for discrimination than shape of individual peaks.

B. Discussion

As an exploratory experiment, the study necessarily uncovered more questions than it answered. It established the importance of studying human learning in relation to the general problem of target classification, and suggested some avenues of approach to further research in the field. The variables represented in the experiment are only a few of many which should receive careful attention.

When vision and hearing are used as human input channels, there are several different relationships their stimuli may have to the response category which is to be the human output. In the present experiment, there was only one very simplified response category, switch-pressing. Stimuli in each modality were presented as equivalent cues to this class of response. Some of the other relationships which might profitably be explored are: (1) use of the two modalities as independent channels, so that data for one channel will be attached to different responses than data for the other; (2) use of the two modalities as supplementary channels, in which case data for one channel may change the response significance of data for the other, and (3) use of the two as complementary channels, so that input data in both channels would

be a necessary antecedent for the occurrence of a particular response.

The sensory parameters of the stimulus patterns used in this type of study should, of course, be explored over a wide range. It is probable that a combination of two approaches would be most productive; analysis of discriminable target referents in actual echo-returns combined with synthesis of stimulus patterns representative of those referents which it is desired to study, without the noise accompaniments of the echo-returns.

The evidence developed by the present experiment for patterning of stimuli, that is, for the formation of compound patterns from aural and visual components, has interesting implications for training as well as operational use of a simultaneous type of display. In situations where the input data is much more difficult to learn in terms of discrimination among patterns than was that of the experiment, it is conceivable that a simultaneous display would result in a more reliable man-machine link, to a practically advantageous degree, than a single aural or visual display. The results of the experiment suggest that training individuals on compound pattern discrimination should be accompanied by training on the components if the situation in which the individuals are to respond may at different times contain both compounds and separate components.

The alert-confirm relationship of the successive type of display has inherent advantages for those operational situations characterized by intermittent activity separated by long periods of inactivity. Operator boredom, and its effect on signal detection, might be counteracted to a useful extent by this relationship.

V. SUMMARY AND CONCLUSIONS

A. Summary

The effects of four displays on the discrimination learning of simulated sonar echo-returns was explored by means of one of several possible input-output relationships. Six hypotheses dealing with the interrelations of the display comparisons, and with the discriminability of the stimulus patterns were tested by means of five 15 subject groups.

B. Conclusions

1. The aural display resulted in the most learning of patterns in a single modality.

2. The simultaneous display produced compound patterns which were learned better than patterns in a single modality presented under any other except the aural display conditions.

3. The simultaneous display produced compound patterns which were learned better than their components.

4. The type of combined display, simultaneous or successive, which might be used in an operational situation would depend upon conditions other than those in the experiment; either leads to about the same amount of learning of patterns in a single modality.

5. Number of amplitude peaks was an easier cue for discrimination than shape of the peaks, so far as the stimulus patterns used in the experiment were concerned.

6. The experiment demonstrated the importance of studying human learning variables in relation to target classification which relies on electronic intelligence information.

VI. APPENDIX

Table 3

Statistical Translation of the Hypotheses: t-ratios

	Predictions Obtained Means		Results Pos.	Neg.	t-ratios
	Hypothesis 1				
a.	III Mc (3.55) will be significantly larger than	III Ma (2.54)	*		3.377
b.	III Mc (3.55) " " " " "	III Mv (2.82)	*		2.741
c.	III Mc (3.52) " " " " "	I Mc (3.27)			
d.	III Mc (3.62) " " " " "	II Mc (2.41)	*		4.144
e.	III Mc (3.55) " " " " "	IV Mc (2.80)	*		2.278
f.	III Mc (3.55) " " " " "	V Mc (3.03)			
	Hypothesis 2				
a.	IV Ma (2.57) " " " " "	III Ma (2.54)			
b.	V Ma (2.70) " " " " "	III Ma (2.54)			
c.	IV Mv (2.11) " " " " "	III Mv (2.82)		*	2.320
d.	V Mv (2.57) " " " " "	III Mv (2.82)			

Table 3

(continued)

	Predictions Obtained Means		Results Pos.	 Neg.	 t-ratios
	Hypothesis 3				
a.	IV Mav will be significantly larger than (8.47)	V Mva (8.42)			
b.	IV Mv - IV Ma will be significantly (2.11) (2.57) larger than	V Mv - V Ma (2.57) (2.70)			
	Hypothesis 4				
a.	II Mv will be significantly larger than (7.17)	I Ma (10.74)		*	3.570
b.	II Mv " " " " " (2.05)	I Ma (3.40)		*	5.161
c.	II Mc " " " " " (2.41)	I Mc (3.27)		*	2.763
d.	III Mv " " " " " (2.82)	III Ma (2.54)			
e.	IV Mv " " " " " (2.11)	IV Ma (2.57)			
	Hypothesis 5				
a.	III Mv " " " " " (2.82)	II Mv (2.05)	*		2.458
b.	III Ma " " " " " (2.54)	I Ma (3.40)		*	2.300
c.	M(IV Ma, V Ma) " " " (2.63)	I Ma (3.40)			
d.	M(IV Mv, V Mv) " " " (2.34)	II Mv (2.05)			

Table 3

(continued)

Predictions Obtained Means	Results Pos.	 Neg.	 t-ratios
Hypothesis 6			
a. M(C) will be significantly larger than M(D) (9.97) (8.65)	*		1.983
b. M(C) " " " " " M(A) (9.97) (6.32)	*		5.236
c. M(C) " " " " " M(B) (9.97) (7.86)	*		3.027
d. M(E) " " " " " M(D) (10.97) (8.65)	*		3.328
e. M(E) " " " " " M(A) (10.97) (6.32)	*		6.670
f. M(E) " " " " " M(B) (10.97) (7.68)	*		4.461

Note: 1. The degrees of freedom for the t-ratios vary, since some were within subjects comparisons and others were between subjects comparisons. Where possible, t-ratios were done by the critical difference method, using the best available estimate of the population variance.

2. Only those t-ratios significant at the p = .01 level or the p = .05 level are reported. The t-ratios significant at the p = .01 level are underlined.

3. The mean for III Mc in predictions c and d differs from that for III Mc in predictions a, b, e, and f, Hypothesis 1, because it is based on an n of 13 instead of 15. It was necessary to eliminate the compound tests in the third order position in the counterbalancing series for predictions c and d since there is no comparable third order position in the test series for display groups I and II.

* * * * *